BIG CREEK HYDROELECTRIC SYSTEM, POWERHOUSE 1
(Big Creek No. 1)
North Bank of Big Creek, 100 feet from Big Creek Road
Big Creek
Fresno County
California

HAER CA-167-E
HAER CA-167-E

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

FIELD RECORDS

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240-0001

was complete.[20] Foundation work was finished in March 1913, and construction of the structure occupied the late spring and early summer. On July 18, 1913, the roof was completed, followed by installation of the hydraulic and electric machinery. The plant was first started up on October 14, 1913, but was not paralleled with the Pacific Light and Power system until the completion of the transmission line to Los Angeles on November 1.[21] This date was somewhat later than the originally planned completion date of July 1, 1913.[22]

HISTORICAL CONTEXT

California and Electrical Development of the West

California holds an important place in the history of hydroelectric power generation. Despite relatively low rainfall, especially in the southern regions, the high heads available in the state's mountainous terrain made waterpower important in California's industrial development. The mining industry pioneered the development of dam, flume, and penstock technologies at an early date, while Lester Pelton's development of the Pelton wheel in the 1880s dramatically increased the efficiency of the waterwheel in high head settings.[23] In California, however, this energy was typically located in remote areas far distant from urban centers, restricting its use to industries located nearby.

The development of Thomas Edison's integrated system of dynamos, lamps, and circuitry after 1880 led to a boom in urban electrification. However, widespread dependence on direct current, which had a high rate of transmission loss, made the usefulness of electricity dependent on proximity to a central station. The introduction of alternating current transmission and voltage transformers by George Westinghouse after 1886, however, opened up the possibility of transmitting electricity over long distances.[24] Much of the world's pioneering work in AC transmission took place in California, with early world records for distance and voltage set by transmission lines in Bodie (Standard Consolidated Mining Company, 1891), San Antonio to Pomona (San Antonio Light and Power, 1892), and Folsom to Sacramento (Horatio Livermore, 1893).[25]

Once the potential for connecting hydraulic and electrical power was demonstrated by Westinghouse's development at Niagara Falls (1895), hydroelectric development began in earnest, and nowhere more intensely than in California. Record-setting developments included the first 33 kilovolt (kV) transmission by Southern California Edison's Santa Ana No. 1 plant (1898); use of a 1,300' head in the Mount Whitney Power Company's plant (1899); and, superlatively, the 140-mile, 60kV Colgate transmission line built by Bay Counties Power

[20] Stone and Webster Construction Company, "Progress of the Big Creek Initial Development: Report to Pacific Light and Power Corporation, January 1, 1913," 3, available in Water Resources Library, University of California, Berkeley.
[21] Redinger, *Story of Big Creek*, 31.
[22] Stone and Webster, "Progress," 3.
[23] Hay, *Hydroelectric Development*, 6.
[24] Hay, *Hydroelectric Development*, 9.
[25] Hay, *Hydroelectric Development*, 19, 28.

Company in 1901.[26] "California," claimed the journal *Electrical West* in 1912 "is the birthplace of real long-distance power transmission on this continent."[27]

Southern California Edison's Big Creek project, begun in 1911, was the apex of early twentieth century hydroelectric development in California and was among the world's largest hydroelectric systems at the time of its construction. The system set successive world records for highest voltage ever used in commercial transmission: 150kV (1913) and 220 kV (1923). Powerhouse 1 and Powerhouse 2A had among the highest heads used in North America – 2,131' and 2,418' respectively. In 1929, at the end of the great expansion of the Big Creek system, the five Big Creek powerhouses (1, 2, 2A, 3, and 8) each held a place among the top ten California hydroelectric plants for kilowatts and horsepower generated.[28]

Origins of the Big Creek System

The Big Creek system was the brainchild of visionary engineer John Eastwood (1857-1924), who first identified the Big Creek and San Joaquin River systems as an ideal location for a series of storage reservoirs and power plants. Eastwood was born in Minnesota and came to California in 1878 to work on the Pacific extension of the Minneapolis and St. Louis railroad. After establishing a private engineering firm in Fresno in 1883, Eastwood turned his attention to the Sierras. In 1893 he first visited the present location of Big Creek town, and saw its potential as the anchor point of a huge hydroelectric generating system. However, demand, distribution, and transmission networks for such quantities of power did not yet exist in California.[29]

By 1895, Eastwood had shown that high-head hydroelectric plants were feasible in the area by developing a plant further down the San Joaquin River for the San Joaquin Electrical Company (today the site of Pacific Gas & Electric Company's Wishon powerhouse). The San Joaquin Electrical Company soon went bankrupt, however, and in 1900 Eastwood turned in earnest to planning and surveying the Big Creek system, securing water rights and identifying locations for tunnels, dams, and power plants.[30] These plans, however, only came to fruition when Eastwood's engineering vision was combined with Southern California capital, in the person of Henry Huntington.

Huntington was born in 1850 in Oneonta, New York. His uncle Collis P. Huntington was the force behind the consolidation of the Southern Pacific Railroad. Determined to make his own mark on the industry, Huntington sold his Southern Pacific stock in 1901 and moved to Los Angeles. He became a major figure in the development of the Los Angeles region through his

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[26] Hay, *Hydroelectric Development*, 30; Hughes, *Networks of Power*, 277

[27] Quoted in Hughes, *Networks of Power*, 265.

[28] P.M. Downing, O.B. Caldwell, E.R. Davis, W.G.B. Euler, and C.C. MacCalla, "Report of the Sub-committee on Water Development on the Pacific Coast," in National Electric Light Association, *Papers Reports and Discussions, Hydro-Electric Transmission Sections Technical Sessions, National Electric Light Association Thirty-Eight Convention* (San Francisco: National Electric Light Association, 1915), 594-601; Federal Power Commission, *Directory of Electric Generating Plants* (Washington, D.C.: Federal Power Commission, 1941), 14-21; U.S. Department of Energy, *Inventory of Power Plants in the United States, 1981 Annual* (Washington, D.C.: U.S. Department of Energy, 1982), 41-54.

[29] Shoup, *Hardest Working Water*, 55-59; Whitney, "John Eastwood," 38, 41.

[30] Shoup, *Hardest Working Water*, 60-62; Redinger, *Story of Big Creek*, 6.

consolidation of street railroads, public utilities, and large real estate holdings. By acquiring land and then connecting it to the metropolis by electric railroad, Huntington was able to sell suburban parcels at hefty profits.[31]

Huntington's expanding network of street railroads depended on a reliable and inexpensive source of electrical power. In 1902, he joined with Allan C. Balch and William G. Kerckhoff to found Pacific Light and Power Company for this purpose. Kerckhoff was born in 1856 and moved to Los Angeles with his family in 1878. Through his father's lumber company he acquired an interest in the San Gabriel Valley Rapid Transit Railway, which was later absorbed by the Southern Pacific. Balch, born in New York in 1864, was trained as an electrical engineer and managed a steam-electric plant in Portland before moving to Los Angeles in 1896. Together, Balch and Kerckhoff founded the San Gabriel Electric Company, which brought them into contact with Henry Huntington.[32]

Huntington was looking for sources of electrical power, while Balch and Kerckhoff had successfully developed a hydroelectric plant on the San Gabriel River, and were proceeding with plans for another on the Kern River, 100 miles to the north. In 1901 and 1902 the three men founded Pacific Light and Power Company with the short-term aim of supplying cheap power to the street railroads, with the eventual aim of consolidating the electric utilities of the greater Los Angeles area into a monopoly.[33] Initially, 51 percent of the company was owned by the Los Angeles Railroad, in which Henry Huntington held a 55 percent interest, with the remainder owned by the Southern Pacific. Balch and Kerckhoff owned 40 percent of Pacific Light and Power, and appointed three of the seven directors, while Huntington named the rest. The intimate relationship between power and railroads at this early date is evidenced by the fact that the power company was formed as a subsidiary of the railroad, and not the other way around.

Kerckhoff and Balch acquired Fresno's San Joaquin Electric Light and Power in late 1902 as a large source of low cost power that could meet the projected demands of the fast-growing metropolis of Los Angeles.[34] At the time, John Eastwood was Vice President and Chief Engineer of San Joaquin Electric Light and Power. Balch and Kerckhoff were receptive to Eastwood's plans for Big Creek, and hired him in July 1902 to fully plan the system. Eastwood immediately began filing water rights claims and by late 1903 had claimed over 410,000 miner's inches of water in the basin.[35] By 1905, Eastwood had prepared plans for a system of powerhouses and transmission lines that by his estimate would offer considerable savings over similarly sized steam plants.[36] Pacific Light and Power's directors, however, were uncertain whether existing demand could absorb the huge quantities of power that Eastwood's proposed

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[31] Shoup, *Hardest Working Water*, 66.
[32] Shoup, *Hardest Working Water*, 67-69.
[33] Shoup, *Hardest Working Water*, 74.
[34] Shoup, *Hardest Working Water*, 71.
[35] Shoup, *Hardest Working Water*, 75.
[36] John S. Eastwood, "Comparative Estimate of Cost of Water-Power Transmission Plant vs. Steam Plant, for W.G. Kerckhoff, President, Pacific Light and Power Company," 1905, Document No. 12871, in History and Information File, Northern Hydro Division Headquarters Library, Big Creek, California.

plants would generate, and decided in 1903 to prioritize steam development over hydroelectric. As a result, the period up to 1910 saw little progress on the Big Creek project.

Despite this delay, Eastwood continued to file water claims and began securing permits from the U.S. Department of the Interior to develop the hydroelectric plants, which are located on Federal land on the Sierra National Forest. Road permits were granted in 1903-1904 and comprehensive permits for the initial Big Creek development issued in 1909.[37] In 1906 Pacific Light and Power reached an agreement with Miller and Lux, a land and livestock company holding much of the downstream water rights on the San Joaquin River, and in late 1905 construction of a road from Shaver (then a timber camp) to the Big Creek basin was begun. Another route, from Auberry to Camp 1 (the site of today's Big Creek town), was begun in 1908.[38]

By 1905, Eastwood had outlined his vision for the initial development of the Big Creek system. He identified the later locations of Powerhouses 1 and 2 as the sites for two powerhouses with 2050 and 1861 feet of head, respectively. In his proposal, each plant would have six 7,500 horsepower (hp) water wheels generating over 40,000 hp of electricity. His projected power lines were to transmit either at 66kV or 88kV. His design for the powerhouses proposed a separation between the generators, transformers, and transmission equipment:

> The portion to be blasted out will not be great, as the buildings will be narrow, and the outer walls will be carried up, and the floors leveled with broken rock, the buildings rising one above another in steps, the generator house first, the transformer house next, and the line house and tower at the top…
>
> The generator house will be located nearly on a level with the bed rock at the creek, and parallel with the creek channel, the inner edge being blasted out of the bluff, and the outer edge being built up to bring the floor up to a level.
>
> This building will need to be 210 feet long, inside and 40 feet wide, with an alcove to accommodate the exciters and the switching gallery… The transformer house will be separated from the generator room by a fire wall the entire hight *[sic]* of the building, and separate stalls provided for the transformers, and will lighted *[sic]* from a skylight and from windows arranged above the traveling crane, and at the ends of the building, and will be 210 x 30 feet inside.
>
> The line house and tower, will contain the lightning arresters, and the main transmission line terminals, and will be built with a dead wall in front, and lighted from the upper side, and will be 60 feet long and 30 feet wide inside, surmounted by a tower 24 feet square inside, provided with open ports for the exit of the lines.

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[37] Shoup, *Hardest Working Water*, 82.
[38] Shoup, *Hardest Working Water*, 83.

> There is no reason why, with the almost ideal conditions to be met at this site, it should not be a model plant, not only from the point of permanency, economy and certainly of output, but in the way of tasteful and convenient design and architecture as well, in as full a degree as consistant *[sic]* with its location and uses.[39]

Although the eventual design of Powerhouses 1 and 2 departed considerably from Eastwood's original vision, many of the principles laid out in this initial design remained the same: the creekside location, the length of the building, the use of fire walls to separate equipment, and the separation of transformers in stalls. Eastwood was in fact ahead of his time in proposing the physical separation of different functional elements of the plant, an approach to powerhouse construction that become standard after the early 1920s.

He also identified locations for Powerhouse 3 and a larger Shaver Dam (then owned by the Fresno Flume and Lumber Company), and anticipated the use of water from Mono Creek and Mammoth Lakes. As we will see below, all of these facilities were eventually constructed in the locations proposed by Eastwood – although the power eventually supplied by the system was considerably more than even he anticipated.[40]

By 1909-1910, Huntington, Kerckhoff, and Balch began seriously considering the fulfillment of Eastwood's hydroelectric plans. A consultant estimated the cost of the two initial power plants at $12.34 million. To ensure the soundness of the investment, Huntington hired the Chief Engineer of the Southern Pacific Railroad to estimate the potential revenues from the project. The assessment concluded that the Big Creek system would lose money. Rather than canceling the project, however, Balch and Kerckhoff ordered construction of a weir to more precisely calculate water flows on Big Creek.[41]

Meanwhile, Huntington was taking steps to raise capital for the project. Pacific Light and Power Company was recapitalized in late 1909 with the help of eastern bankers and sold new bonds to raise money for the Big Creek project. At the same time, Huntington eliminated the Southern Pacific Company from the project by trading one of his interurban electric lines in Los Angeles for the Southern Pacific's 45 percent stake in the Los Angeles Railroad, Pacific Light and Power's holding company. In 1910, Balch exercised his option to buy the plans, water rights, and permits for Big Creek, all of which were held in Eastwood's name. Eastwood received 10 percent of the stock of the new Pacific Light and Power Corporation.[42] Huntington, however, used special assessments on shareholders to force Eastwood to sell his stock cheaply, depriving him of his hoped-for wealth. Despite his visionary role in designing the Big Creek project, Eastwood was excluded from involvement in its construction and ultimately received no financial reward for his work. Balch and Kerckhoff also sold their interests to Huntington about

[39] John S. Eastwood, "Progress Report for 1903-1904 of Right of Way Surveys and Outline Plan for Power Plant No. 1," 1904, 38-39, in Folder 11, Box 302, Southern California Edison Papers, Huntington Library, San Marino, California.
[40] Eastwood, "Comparative Estimate."
[41] Shoup, *Hardest Working Water*, 85-86.
[42] Shoup, *Hardest Working Water*, 85.

this time, leaving him with full control of the company. About the same time, in October-November 1911, Huntington secured financial backing from a syndicate of New York bankers that allowed construction to proceed.[43]

Initial Construction, 1910-1913

Once the financial resources to construct the project had been secured, construction was ready to begin. Pacific Light and Power, however, lacked the large workforce or engineering expertise to quickly begin construction. Instead, it hired the Boston-based Stone and Webster Construction Company to design and manage the construction. The contract with Stone and Webster covered the construction of the 56-mile San Joaquin and Eastern Railroad, three dams to create Huntington Lake, Powerhouses 1 and 2, the 240-mile transmission line to Los Angeles, and the necessary forebays, tunnels, and penstocks.[44] Authorization to begin construction of the railroad was given on January 26, 1912.

Work on the railroad proceeded in a climate of secrecy, since all of the necessary rights-of-way had not yet been secured. Construction of the railroad raised difficult engineering problems. Most famously, one section of the route passed across a bedrock face on tracks bolted directly to the stone. The railroad was completed on July 12, 1912 – only 165 days after work began.[45]

The development as executed by Stone and Webster followed Eastwood's plans in the main, although Stone and Webster's engineers favored different architectural and engineering solutions: their engineers built Cyclopean masonry dams with gravity sections rather than his proposed earth dams, and combined the generation and transmission facilities in a single structure rather than separating them in detached buildings as Eastwood had proposed.[46]

In March 1912, blasting for the dam sites and tunnels began. Over the summer of 1912, 3,500 men were at work in 12 camps scattered across the construction area. Dam and tunnel construction continued until the end of 1912. Huntington, Balch, and PLP Vice President George C. Ward visited the site of construction in July 1912, in what was to be Huntington's only visit to Big Creek. Preparations for constructing Powerhouses 1 and 2 commenced in late 1912, when Stone and Webster established a sawmill to cut timber logged out of the area. The lumber would be used for construction forms for the powerhouses. At the end of 1912 excavation for the foundations of Powerhouse 1 were well underway.[47] At the same time, the process of securing final permits from the Department of Agriculture (the parent agency of the U.S. Forest Service) continued. Ward filed the application for a final Power Permit on July 16, 1912 with amendments in November. The Department of Agriculture was apparently slow to respond, for Southern California Edison archives contains a letter of March 1913 noting that issuance of the permit was an urgent matter, since construction work was well underway. It was

[43] Shoup, *Hardest Working Water*, 85, 92.
[44] Redinger, *Story of Big Creek*, 11; W. Sohier, *The Big Creek Project, A History, December 27, 1917*, typescript, 9-10, in Folder 7, Box 302, Southern California Edison Papers, Huntington Library, San Marino, CA.
[45] Shoup, *Hardest Working Water*, 95.
[46] Eastwood, "Progress Report."
[47] Stone and Webster, "Progress," 3.

not until July 16, 1913 that the Department of Agriculture finally issued the final power permit for Big Creek Powerhouses 1 and 2.[48]

The pivotal construction year of 1913 opened with bad weather and a general strike. Working conditions were difficult: workers complained of long days and bad food, while typhoid and other diseases struck the camps. Accidents killed or maimed several workers, sparking a visit from the state labor commissioner in late 1912.[49] When several men were fired for trying to attack one of the cooks, over 2,000 men went out on a strike led by members of the Industrial Workers of the World, a radical anarcho-syndicalist union. Demands included time-and-a-half pay for overtime, hot water in the washrooms, better sleeping quarters, access to doctors, and better food. The strike began at Camp No. 3 on January 7 and spread quickly to the others. In response, Stone and Webster closed the mess halls, locked out its employees, and suspended work at Big Creek. Almost 2,000 men were fired outright, and striking workers had no choice but to leave the area.

The record snowfall that fell that week provided a convenient excuse for suspending the project while Stone and Webster hired a new workforce. By January 25, construction on the powerhouses had resumed.[50] Between the strike and the bad weather, however, the Big Creek project had fallen behind schedule. Originally set for completion on July 1 and October 1, 1913, Powerhouses 1 and 2 were not completed until November and December. This delay reduced the projected revenues from the plants, requiring Pacific Light and Power to raise additional funds to complete construction and causing the temporary layoff of some of the construction workforce.[51]

Powerhouse 1 was built between March and July 1913, and went on line on October 14, 1913. The powerhouse structure was built in just three months, with the roof finished on July 18, 1913.[52] Construction of Powerhouse 2 proceeded simultaneously but was about two months behind Powerhouse 1. The structure of Powerhouse 2 was almost complete in mid-October of 1913. However, on October 17, 1913, a fire swept through the upper floors of the nearly-complete powerhouse, destroying part of the roof, the internal partitions on the upper floors, and some of the equipment. This fire seems to have been begun accidentally in the small saw mill attached to the construction site, though Southern California Edison's 1922 Valuation of Powerhouse 2 suggests that it was of an 'incendiary nature,' hinting that it may have been a case of arson.[53] Powerhouse 2 Unit 1 did not go online until December 8, 1913, and Unit 2 began transmitting on January 11, 1914.[54]

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[48] Sohier, "The Big Creek Project," 26. More information on the Big Creek permits up to 1957 is held in Folder 6, Box 302, Southern California Edison Collection, Huntington Library, San Merino, California.
[49] Shoup, *Hardest Working Water*, 127.
[50] Shoup, *Hardest Working Water*, 132.
[51] Stone and Webster, "Progress," 3; Kelley, *Valuation*, 8.
[52] Redinger, *Story of Big Creek*, 31-32.
[53] "Fire at Big Creek Causes Damage of $10,000," *Fresno Morning Republic*, October 20, 1913.
[54] Redinger, *Story of Big Creek*, 31-32.

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When the initial phase of Big Creek was complete, the two powerhouses had four generating units producing 80,000 horsepower and using some of the highest heads in the country. At 240 miles long, the power lines connecting Big Creek with Los Angeles were among the world's longest, and set a new record for using 150kV in commercial transmission. The vision of Big Creek as an integrated system of plants which could be added to was also ahead of its time and anticipated the interconnected systems that characterize power production and transmission today.

Other large plants built about this time, such as Keokuk (Illinois) and Conowingo (Maryland), generated more power, but none were built under conditions as difficult as those at Big Creek. The difficult mountain terrain, high heads, and huge turbines gave the Big Creek plant an essentially experimental character. *Electrical World* recognized the feats achieved in the initial construction of the system as "one of the most advanced contributions of the engineer to the welfare of civilization."[57]

Intermission, 1914-1919

While Big Creek Powerhouses 1 and 2 were designed for later expansion, the onset of the European war in late 1914 affected both the American credit markets and power consumption. It became difficult for companies such as Pacific Light and Power to raise money for capital projects, while electrical demand in Los Angeles was not growing fast enough to require immediate construction of additional power plants or generating units.[58]

Despite this relative lull, some construction did continue at Big Creek. Crews began work on Tunnel 3, which was to connect Powerhouse 2 to the proposed Big Creek No. 3 development. However, only 2050' of tunnel were bored between July 1914 and February 1920. In summer 1917, the three dams at Huntington Lake were raised to an elevation of 6950', increasing the lake's storage capacity and allowing the later installation of a third generating unit in Powerhouse 2.[59]

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[55] "Fire at Big Creek."
[56] Redinger, "Story of Big Creek," 31-32.
[57] "The 150,000-Volt Big Creek Development-I," *Electrical World*, January 3, 1914, 33.
[58] Shoup, *Hardest Working Water*, 153.
[59] David H. Redinger, "Progress on the Big Creek Hydro-Electric Project, Part I," *Compressed Air Magazine*, December 1923, 722.

More significant for the future development of the Big Creek system was the 1917 merger between Pacific Light and Power and Southern California Edison (SCE). Henry Huntington had dreamed since at least 1902 of consolidating southern California utilities under his control. The merger, which was accomplished through a swap of PLP and SCE stock, made sense from a business point of view. PLP had extensive street railroad interests but limited residential service, and the Big Creek plants provided more electricity than it could use. Edison, on the other hand, had a rapidly expanding residential business and was facing a looming shortfall of generation capacity. The two systems complemented each other, as the California Railroad Commission observed when it approved of the merger in 1917. As *Electrical World* noted at the time,

> this merger of what are really vast interests is undoubtedly along the lines of wise business policy. The two electric companies have been operating side by side in a rapidly growing territory, competing keenly for business in a number of centers, and to some extent duplicating investment and wasting energy which could be better utilized in other directions.[60]

The newly merged company had two vice presidents from the Pacific Light and Power side, R.H. Ballard (formerly corporate secretary) and George C. Ward (formerly vice-president), while Henry Huntington, his son Howard, and his lawyer W.E. Dunn each took seats on the Board of Directors.

After the end of the First World War in late 1918, an economic boom began. Capital was again available, and rapid urban and industrial growth in Los Angeles had radically increased demand for electricity. A new source of energy was needed quickly. As a result, the previously modest expansion plans for Big Creek were accelerated.[61] In October 1920 Southern California Edison applied to the California Railroad Commission for approval of their proposal to expand Powerhouse 1 and construct two new powerhouses, to be called Powerhouse 3 and Powerhouse 8. Permission was granted in Railroad Commission decision 8569 on January 20, 1921.[62]

The original plans for Powerhouse 3 had called for it to utilize a head similar to Powerhouses 1 and 2 (1500'). The development of more efficient vertical turbines in the intervening years, however, made it possible to extract more power from a lower head. As a result Edison decided to divide the head originally intended for Powerhouse 3 into two power plants. Powerhouse 8 (so numbered because numbers up to 7 had already been used in Federal permit applications) was to be built first at the junction of Big Creek and the San Joaquin River. The construction of Powerhouse 8 in early 1921 set off a period of continuous expansion of the Big Creek system that lasted, almost without interruption, until 1929.

The Big Creek Community on the Eve of the Great Expansion

The 1920 United States Census was conducted just as the great expansion of the Big Creek system was getting underway. While the population of the region would eventually swell to

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[60] "Merger of California Hydroelectric Systems," *Electrical World*, December 9, 1916, 1134.
[61] Shoup, *Hardest Working Water*, 162.
[62] Noted in an untitled memorandum in Folder 6, Box 302, Southern California Edison Collection, Huntington Library, San Marino, CA.

over 5,000 at the height of construction work, only 535 people lived in the "Cascada Precinct" of Fresno County when the census was conducted in 1920. The precinct included the town of Cascada (renamed Big Creek in 1926) and the nearby construction camps. The census data provides us a snapshot of the community and its demographics that provides some insight into the social world of Big Creek in the early period of its operation.[63]

The Big Creek community in 1920 was overwhelmingly male, with 426 adult men but only fifty-eight women and fifty children. There were only fifty-two married couples in the community, although ninety-four men were listed as married. While some of the married couples took on individual boarders, most of the men lived in boarding houses or bunkhouses with from ten to fifty-six occupants. This dense occupancy is reflected in the fact that the area contained only seventy-nine dwellings for 535 people.

Twenty-three of the married couples had children. Of the fifty-eight women residing in the Cascada precinct, fifty-two were married, three widowed, and three single. Two of the single women, aged 19 and 21, were the eldest daughters of a foreman. The other, aged 21, was the grammar school teacher. Two of the widowed women, aged 61 and 60, lived in Big Creek with their working sons. A 35 year-old widow, living with her 7-year-old son, was the proprietor of one of the boarding houses.

The vast majority of employment in the Cascada Precinct was through Southern California Edison: of the 432 adults with jobs, 365 worked for the "power company" or within a "power company camp". Another thirty-five men worked for the San Joaquin and Eastern Railroad, also owned by Southern California Edison. Twenty men worked in construction, at a warehouse, or in a sawmill – possibly the employees of the Fresno Lumber and Irrigation Company in the town of Shaver, now Shaver Lake. The remaining residents, twelve in number, were shopkeepers, hotel operators, or providers of other basic services. Cascada, in other words, was a company town fully dependent on the Big Creek powerhouses.

Over half (189) of the Edison employees were recorded in the 1920 census as "laborers" Others had more skilled employment as carpenters (35), mechanics or machinists (18), engineers (18), electricians (10), teamsters (13), and clerks. Other jobs included blacksmiths, timekeepers, painters, miners, riggers, pipefitters, and cement workers. Supporting the community were fourteen cooks, twelve waiters, five storekeepers, four boarding house workers, two nurses, a doctor, and a grammar school teacher. The average age of Edison employees at the time of the census was 37.

Most residents of the Big Creek area in 1920 were native-born Americans, and all listed their race as "white." Only around one third were foreign born, and most of these had come from northwest Europe. More than twenty nations of origin were represented in the community. The largest group was Irish (21), followed by English (16), Swedish (14), Canadian (13), German (12), Scottish (8), Italian (8), and Russian (7). All of the foreign-born came from either Europe

[63] Fourteenth Census of the United States, Cascada Precinct, Fresno County, California.

or Canada, except one from Siberia, one from Chile, and one from South Africa. Over two-thirds of the foreign-born workers, however, had been in the U.S. more than ten years.

Powerhouse 8: The "Ninety Day Wonder"

This community would soon be swelled by the addition of thousands of new construction workers. The great expansion of the Big Creek system began in early 1921, when the construction of Powerhouse 8 began. Excavation for the foundation of Powerhouse 8 took place between January and early May, with the first concrete was poured for its foundation on May 12. The turbine parts were assembled as concrete was being poured for the powerhouse structure, and installation of Unit 1 commenced in June. On August 11, Powerhouse 8 began generating power, and was connected to the system on August16.[64]

Powerhouse 8 was a pioneer facility in several respects: it was the first commercial powerhouse ever designed for 220kV transmission, it was among the first to use the improved Francis-type vertical reaction turbine, and its generation capacity from the single initial turbine almost matched that of both units in Powerhouse 1 (27,000kW compared to 28,000kW). Powerhouse 8 also set records for the speed of construction, which continued 24 hours per day, 7 days per week and earned the plant the moniker of the 'Ninety-day wonder.'[65]

Powerhouse 3: "The Electrical Giant of the West"

In September 1921, soon after the completion of Powerhouse 8, construction began on the tunnels, forebays, and penstocks for Powerhouse 3.[66] The revised plan for this station was similar to that of Powerhouse 8: it would also use Francis-type vertical reaction turbines operating under a relatively low head (827'). The engineering challenges of Powerhouse 3 were considerable, requiring 30,000' of tunnel work, the blasting of a six-mile road into a sheer granite face, and extensive foundation excavation. This work continued throughout 1922.

On November 15, 1922 the excavation for the Powerhouse 3 forebay was complete and the erection of concrete forms was begun.[67] The dam was completed in February 1923. Excavation for the foundation of the powerhouse started June 5, 1922 and was completed January 10, 1923. The three initial units of Powerhouse 3, "the electrical giant of the West," were placed online on September 30, October 2, and October 5, 1923.[68] Though Big Creek 3 was planned for eventual expansion to six units, the structure as built in 1923 had room for only four, while only three were installed at first. Even with only three units, however, Big Creek Number 3 was the largest hydroelectric plant in the west, with an aggregate capacity of

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[64] "Big Creek No. 8 Hydro-Electric Unit Completed," *Journal of Electricity and Western Industry*, August 15, 1921, 160.
[65] Shoup, *Hardest Working Water*, 190; "First 220,000-Volt Station Completed," *Electrical World*, 117.
[66] "Southern California Edison Company to Start 150,000-Kw. Station," *Electrical World*, September 24, 1921, 636.
[67] Redinger, "Progress," I, 838.
[68] David Redinger, "Progress on the Big Creek Hydro-Electric Project, Part V," *Compressed Air Magazine*, September 1924, 991.

75,000kW. The powerhouse also incorporated several innovations in design, such as an outside switchyard and a two-level generating floor that eliminated the need for a basement.[69]

Additional Units and 220kV Transmission

Each of the Big Creek powerhouses was designed for later expansion. Work on a third generating unit at Big Creek No. 2 was authorized in late 1918 and began in summer 1920. Structural work was completed that November, and the new unit was paralleled to the system on February 1, 1921. The Shaver Tunnel was also begun in February 1920 and completed in May 1921. This tunnel diverted water from Shaver Lake into the Big Creek drainage, allowing its use in Powerhouse 2 and the plants below. Initially this water was simply diverted into the Powerhouse 2 forebay, though it was later used in Powerhouses 2A, 3, and 8 upon their completion.

Work to convert Big Creek's 150kV transmission system to 220kV was completed on May 6, 1923, when the Big Creek system began transmitting at the highest voltage used commercially anywhere in the world.[70] In July 1923 Powerhouse 1 was expanded to add a third unit, which was brought on line on July 12. In late 1924 and 1925 Powerhouses 1 and 2 were expanded to their full planned capacity by the addition of a fourth unit to each. This addition required extension of the powerhouse structures by 56' each.[71]

Florence Lake, the Mono-Bear Conduit and Shaver Dam

The later 1920s saw efforts to increase the available water in the Big Creek system by increasing storage capacity and drawing from adjacent watersheds. Between 1925 and 1928, tunnels and dams were built from Mono Creek, Bear Creek, and the south fork of the San Joaquin, while the dam at Shaver Lake was raised to increase its storage capacity.

The years 1925 and 1926 saw the construction of the dams that created Florence Lake on the south fork of the San Joaquin River. Work on the Florence Lake Tunnel (later named the Ward Tunnel for Edison President George C. Ward), which connected the south fork watershed to the Big Creek system, had begun in 1920 and was finished in April 1925. For the dam, a multiple-arch design was chosen, a type pioneered by John S. Eastwood. Construction began in March and was completed in November 1925, although the dam was raised again in 1926.[72] The Mono-Bear diversion drew water from Bear and Mono creeks, located downstream from Florence Lake, into the Ward Tunnel and thence into Huntington Lake. Constructed between 1925 and 1927, these tunnels required excavation through solid granite.[73]

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[69] "Work Progressing Rapidly on Big Creek No. Three," *Journal of Electricity and Western Industry*, May 1, 1923, 341.
[70] "Transmission at 220,000 volts a Fact," *Electrical World*, May 12, 1923, 1107.
[71] "Big Creek No. 2 Power House Being Extended 56 ft.," *Journal of Electricity* 54 (1925): 297; Southern California Edison, "Memorandum, Hydro Generation, Northern Division, Generator Winding Data Revised to May 13, 1985," 1-2, in History and Information File, Northern Hydro Division Headquarters Library, Big Creek, California.
[72] Redinger, *Story of Big Creek*, 136, 150.
[73] Redinger, *Story of Big Creek*, 149.

Shaver Lake, originally built by the Fresno Flume and Lumber Company as part of their logging and sawmill operation, was raised between 1925 and 1927, expanding the lake to 2,200 acres in surface area. The new Shaver Lake was designed to store excess water from Florence and Huntington Lakes and also to make possible new high-head generating units that would be known as Powerhouse 2A.[74]

Powerhouse 2A and the End of the Great Expansion

The availability of water from Florence Lake and Shaver Lake led to the ambitious expansion of Powerhouse 2. Two additional units were constructed in a new building adjacent and connected to the older building. Powerhouse 2A would harness a 2,418' head, the highest in the Big Creek system and one of the highest in the United States. Construction of Powerhouse 2A began in June 1926 and cost $23 million.[75] Units 1 and 2 went online on August 21 and December 21, 1928, respectively.[76] The 56,000 hp turbines and 46,500kW generators were among the largest in the world at the time of their installation. Although Powerhouse 2A drew water from Shaver Lake and had its own transmission line, the new building was operated from the Powerhouse 2 control room.[77]

When the second unit of Powerhouse 8 went on line in June 1929, the great expansion of the Big Creek system was concluded.[78] Fifteen generating units were in service, with a aggregate capacity of 344,800kW. The system went from generating 213 million kilowatt-hours in 1914 (its first full year of service) to 1.6 billion kilowatts in 1928.[79] From the opening of Powerhouse 1 in 1913 to the end of 1929, the Big Creek system had set a series of records for generation and transmission that earned it a preeminent place among the electrical generating systems of the west and of North America.

[74] Redinger, *Story of Big Creek*, 153.
[75] "Southern California Edison's Advance," *Electrical West*, April 21, 1928, 829.
[76] Southern California Edison, "Memorandum," 3.
[77] Redinger, *Story of Big Creek*, 157; "Southern California Edison's Advance," 829.
[78] "Second Unit Installed at Big Creek Plant No. 8," *Electrical West*, July 1, 1929, 38.
[79] Southern California Edison, *1928 Annual Report, Big Creek Division*, 21, in History and Information File, Northern Hydro Division Headquarters, Big Creek, California.

Powerhouse	Unit	Capacity (kW)	Installation date
1	1	14,000	1913
	2	14,000	1913
	3	14,000	1923
	4	22,400	1925
2	3	14,000	1913
	4	14,000	1913
	5	14,000	1921
	6	14,000	1924
8	1	22,400	1921
	2	34,000	1929
3	1	25,000	1923
	2	25,000	1923
	3	25,000	1923
2A	1	46,500	1928
	2	46,500	1928
Total	**15**	**344,800**	

Table 1. Big Creek Generating Capacity at the end of the Great Expansion.

Operating the Powerhouses
The degree to which the Big Creek Powerhouses, especially Powerhouses 1 and 2, were experimental technologies can be seen in the daily operators' logs, which remain on file at the plants. The logs reveal how operators dealt with frequent minor mechanical problems, and a few major ones such as penstock breaks. The experience led to innovations in safety procedures, and a focus on accident avoidance that remains a characteristic of Southern California Edison corporate practice today.

JOB CLASSIFICATIONS
Big Creek Nos. 1 and 2 began operation in late 1913 with three to five men on duty. Shifts were initially ten hours, but were reduced to eight hours by 1920. The plants maintained a three-shift schedule: 8am-4pm, 4pm-midnight, and midnight-8am. These rotations were also observed in Big Creek Nos. 3 and 8 when they came on line in 1921 and 1923 respectively. In 1929 the Big Creek division employed forty-nine powerhouse operators in the four plants, at the grades of "shift operator," "operator," "assistant operator," and "probationer." Besides the operators, each powerhouse had a station chief, assistant chief, electrician, machinist, two utility men, and a cook for the boarding houses.[80]

[80] Southern California Edison, *1929 Annual Report, Big Creek Division*, 4, in History and Information File, Northern Hydro Division Headquarters, Big Creek, California; see Southern California Edison, *1927 Annual*

A shift schedule prepared by Big Creek 8 station chief P.H. Hilbert in early 1926 provides an example of how these classifications were divided into shifts:

	{Shift Operator
A.M Shift	{Switchboard Operator
	{Relief Asst. Operator
	{Asst. Station Chief
Day Shift	{Switchboard Operator
	{Machinist or Electrician
	{Shift Operator
P.M. Shift	{Switchboard Operator
	{Relief Operator or Electrician

Hilbert notes that in this arrangement, the station machinist and station electrician would be each available for maintenance work for twelve days each month.[81] Plant daily logs show that other plants also maintained a workforce of three or four men per shift during the 1920s.

OPERATOR TASKS

The main tasks of the powerhouse operators were to adjust power production to fluctuations in load on the overall Edison system, which were dependent on demand in the greater Los Angeles area. Most of the operators' daily tasks, however, were more mundane. They included testing equipment, performing routine maintenance, and cleaning the station. The daily log for December 18, 1926 from Big Creek 3 gives the flavor of the work:

> 12 midnight. Hess, Batzer, Morgan – on.   Thompson – off.
> Station normal. Greased #3 Turbine and swept kitchenette, washroom, and office. Cleaned door, sinks, urinals, bowls, and tubs in main washroom. Emptied trash barrel from machine shop. Burnt all garbage and swept hallway. Cleaned up a few grease stains on gen. floor.
>
> 8am.   Lockyer, Leahy, Horr – on.   Morgan – off.
> Station normal. Repaired opening bolt #15 unit #3 turbine. Took voltage of batt. Swept part of gen. floor. Ran purifier #1 turbine, about 20 gal's water. Wiped #2 turbine.
> Station duties – Horr.

Report, Big Creek Division, 29, in History and Information File, Northern Hydro Division Headquarters, Big Creek, California, for operator grades.

[81] P.H. Hilbert to R.B. Lawton, "Big Creek No. 8 Operating Shift Schedule," Memorandum dated February 19, 1926, in File 29-940.1, Archive Room, Big Creek Powerhouse 8.

4pm. Lee, Strain, Thompson – on. Horr – off.
Station O.K. Wound Venturi Meters. Wiped #1 Turbine and room. Took specific gravity of station batteries and of three cells of A and B Carrier Current Telephone Batteries. Cleaned windows along North wall on generator floor. Cleaned and mopped Kitchenette. Greased #1 H. [house] Set, and water pumps. Changed pumps and compressors.

Station duties – Thompson.[82]

The handwritten logs, which are extant for all four powerhouses, offer meticulous detail about the working lives of their operators during the period of significance.

THE EVOLUTION OF SAFETY PRACTICE

The Big Creek plants deployed cutting-edge technology for their day. Innovation, however, brought with it both hazards and significant technical challenges. In the early period of operation it was the penstocks in particular which provided many of the mechanical failures in the plant. The first such incident occurred at Powerhouse 1 just after 1 am on December 1, 1913, only a few months after the plant was placed in service. A broken penstock joint sent water and debris cascading down the hill and against the back wall of the plant. A.C. Prigmore, the station chief, reported:

> Tried to notify Mr. Lawton by phone but found telephone line shorted and sent up messenger, by this time water had raised up back of building to the window sills and rear door gave way letting flood in between agitators thru be plates of exciters and down into basement. Notified Eagle Rock we would have to shut down at once… Water level in generator pits [was] about a foot and a half above bottom each. Entire length of basement passage filled with sand and rubbish to within a foot of the ceiling, most of it comming *[sic]* in from opening at the West end of building. Sand and rocks covered the floor around the agitators to the top of the foundations.[83]

It took two weeks to return the plant to operative condition.

A worse accident occurred on March 14, 1924, at Big Creek No. 3. A machinist named Johnson and his helper Childs were working on a stuck plunger valve inside Penstock Number 3 when water rushed into the pipe. As the investigative committee reported:

> The helper was close to the manhole and succeeded in getting out. Johnson was caught and killed, his body being torn to pieces and forced out through the turbine relief valve. Water was discharged through the manhole and tore a large hole in the roof, spouting a hundred feet or more above the powerhouse. Part of the air duct for #3 generator was torn away and several windows between the generator room and gallery were broken. The power house was flooded, several inches above the main floor.[84]

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[82] Big Creek No. 3, *Floor Log Volume 11 (1926-1927)*, 97, in Archive Room, Big Creek Powerhouse 3.
[83] Big Creek No. 1, *Daily Log*, December 1, 1913, in Archive Room, Big Creek Powerhouse 1.
[84] Battey *et al.*, letter to Mr. B.F. Pearson.

Johnson's death led to serious introspection in the Big Creek Division. The investigative committee determined that a prime factor behind the accident was because "responsibility [was] divided between operating and construction organizations and the lack of definite rules as to obtaining clearances to do construction and repair work."[85]

In response, the committee recommended improvements to mechanical safety, including mechanical locks on valves and disconnection of electricity to forebay gates during penstock maintenance. They also recommended that definite rules be established for obtaining maintenance clearances. The procedures suggested by the committee were implemented quickly. Powerhouse daily logs and floor logs from the mid-1920s show that new clearance forms were used when maintenance was required on potentially dangerous machinery such as valve pits and governors. The forms named the employee cleared to do the work, and were countersigned by the station chief and dispatcher. The apparatus itself was checked by two further employees, and the final clearance to begin the work signed by the foreman on duty.[86] By ensuring that everyone on duty knew that the work was being performed, the new procedure responded to the failures in communication that were evident in the 1924 tragedy.

Beyond these specific procedures, an increasing emphasis on safe working conditions evolved in the Edison organization during the 1920s. Weekly letter reports and annual reports prepared by Station Chiefs track the number of injuries and days lost to illness, with evident pride when the numbers remained low. The Big Creek Division Report for 1927, for instance, notes only 296 hours off for sickness and 164 off for injury out of 244,078 payroll hours – barely one-fifth of 1 percent.

> A mistake in switching at Big Creek #3 on June 12, 1927, is the only mistake we have to report for the entire Big Creek Division.
>
> Big Creek Plants numbers 1 – 2 and 8 have a clear record for two years. No avoidable accidents to employee in any plant.
>
> A great deal of credit is due to Careful Clubs, Station Chiefs and Employees for the interest they are taking in this branch of the work.
>
> The Big Creek Division Maintenance Crew has a clear record for the last two years. No accidents or mistakes resulting in damage to property or injury to person.[87]

The company established Careful Clubs to provide safety training at each powerhouse, with rewards for stations and individuals for maintaining a clean safety record for periods of six months, one year, and two years. This emphasis on safety practice represents the early phase of the 'safety first' culture that remains a hallmark of Big Creek operations today.

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[85] Battey *et al.*, letter to Mr. B.F. Pearson.
[86] An example of this form can be seen in Big Creek No. 3, *Floor Log Volume 12 (1927)*, 193, in Archive Room, Big Creek Powerhouse 3.
[87] Southern California Edison, *1927 Annual Report*, 28.

RETENTION AND TRAINING

Given the isolation and harsh winter climate of the Big Creek area, recruiting and retention of skilled employees was an ongoing problem. In an early 1922 letter to Southern California Edison's Superintendant of Generation, the Big Creek superintendant wrote of the difficulties he faced:

> As the annual vacation period is near at hand, and it will be necessary at that time to secure relief for the three Big Creek plants, writer would suggest that an effort be made to secure a better class of men than we have been getting in the past. By a better class of men I mean men that have received at least a high school education, and some technical as well if possible, and who have had some mechanical and electrical experience…We have filled our plants with men who in the majority of cases were simply looking for a job. The result is that out of the entire Big Creek operating organization, only a very small percentage have the inclination or ability to fit themselves for responsible positions. The operation of the plants and system is going to become increasingly difficult and complicated by the addition of more and larger plants and units, automatic and semi-automatic protective equipment and increased transmission voltage and in the writer's opinion is going to require a much higher grade of men to successfully and properly handle this equipment than we have been getting the last few years.[88]

Another dimension of the problem was the very high employee turnover experienced at Big Creek, especially in the construction workforce. As the shareholder magazine *Edison Partners* magazine reported in 1923:

> Under the plan of permanent organization of the construction forces the labor turnover on the Big Creek-San Joaquin project has been constantly decreasing, until the average for the past year was forty per cent, and the lowest average for any month twenty-six percent. Good living conditions, excellent food, commissary stores which sell everything from clothing to cigarettes at the same prices that obtain in the large cities, amusements, recreation halls, and greatest of all, that intangible thing which can perhaps be termed "camaraderie" and co-operation tend to contentment among the men, and a desire to consider the project in the nature of a life work.[89]

Despite the rosy prose, the writer concedes an average of forty percent turnover *per month* in the construction workforce, suggesting that many of the workers on the construction jobs at Big Creek during this time found the work too hard, the conditions too isolated, or the pay too low to remain on the job for more than a few months.

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[88] R.B. Lawton to D.D. Morgan, "Operating Force—Big Creek," undated memorandum, probably 1922, in File 29-939, Archive Room, Big Creek Powerhouse 8, Big Creek, California.
[89] "Contented Labor," *Edison Partners*, 6.

This level of turnover may have been specific to the Construction Department.[90] The 1927 Annual Report for the Big Creek Division shows that only thirty-seven of 139 employees left during the year, an annual turnover rate of 26.6 percent (or 2.2 percent per month). Of these, fourteen received transfers within the Edison organization, "in most cases at the request of the company."[91] While this remains a high rate, it suggests that the permanent operating employees at Big Creek had more satisfaction with their work.

To address these problems, Edison implemented programs in the mid-1920s to improve employee education and retention. These often began with basic mathematics. As Big Creek 3 Station Chief O.C. Bangsbury reported in 1927:

> As has been requested, regular classes will be held once a week, starting with Shop Arithmetic. The class has been organized and the first meeting is scheduled to be held Wednesday evening, April 27th. A record is to be kept of each member's work and the progress of the class will be kept in step with that of the classes at the other plants so that men transferring from one plant to another will have no difficulty in continuing with the work.[92]

This policy was implemented throughout the Big Creek system. The 1927 *Annual Report* notes that the number of employees enrolled in study programs increased from 52 percent in 1926 to 68 percent in 1927.[93] At the same time, recruitment of new employees seems to have improved: the 1928 Divisional Report noted that "a number of high grade men have been sent in" but also that "the labor turnover, with this class of men, will be somewhat greater… especially college men, are not satisfied to remain as plant operators."[94] The Big Creek management faced a dilemma: intelligent and educated employees were needed to staff the complex powerhouses, but these same people could also find jobs elsewhere in less isolated places than the mountains around Big Creek.

Edison did make efforts to provide amenities and community-building measures to encourage employees to stay. For instance, losses were anticipated in the commissaries and cookhouses provided for the construction workforce, and the total losses averaged into the cost of construction of the powerhouses.[95]

Though many single men remained in bunkhouses, married men and supervisors often became eligible to live in one of the cottages constructed in Big Creek and at the camps close to the lower powerhouses.

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[90] Employees on the construction jobs were hired through the Southern California Edison Construction Department while the operating employees were employed by the Big Creek Division (later the Northern Hydro Division) of the Power Generation Department.
[91] Southern California Edison, *1927 Annual Report*, 27. Similar figures are reported in the 1928 and 1929 annual reports.
[92] O.C. Bangsbury, "Weekly Letter Report, B.C. 3, April 16, 1927," 2, in Archive Room, Big Creek Powerhouse 3.
[93] Southern California Edison, *1927 Annual Report*, 29.
[94] Southern California Edison, *1928 Annual Report*, 13.
[95] In Arthur Kelley's unit cost developments and price books for the Big Creek plants, these losses are included in the cost of materials and labor, suggesting that the company saw these subsidies as a routine construction expense.

> Their pretty cottage homes, which surround the powerhouses, are equipped with everything that is newest and best in sanitation and electrics. Some of the powerhouse colonies have lawn tennis courts and swimming pools; new books are carried to the powerhouse people from nearby public libraries at frequent intervals, and every now and then a welfare agent comes along with a portable motion picture machine, and shows them the latest "movies."
>
> To "The People Who Live in the Powerhouses" the radio has been a great blessing. They get the news of the day and night as it is read by the broadcasters in the big newspaper offices, and the listen to the entertaining lectures and beautiful concerts which the radio service of the city newspapers is now providing.[96]

The company also sponsored a social institution, the Edison Clubs, which were located at each powerhouse and in Big Creek.[97] The Edison Clubs sponsored dances, kept a library and newspaper subscriptions, and organized other events such as card parties, picnics, film screenings, and miniature golf outings. Outside of Big Creek town, the powerhouses also maintained small commissaries. The clubs were maintained by a combination of employee dues (.50 per month in 1931) and company subsidies.[98]

Big Creek in Context
Between late 1911, when construction began on Big Creek Powerhouse 1, and 1929, when Powerhouse 2A was completed, the Big Creek region was transformed from inaccessible wilderness to an industrial landscape and company town intimately connected to the economy of greater Los Angeles. Each phase of the great expansion was marked by pioneering technical achievements in transportation, dam building, tunnel driving, powerhouse design, and transmission line construction. In the process, a community developed that was marked by a combination of pioneer spirit and corporate paternalism. For many who worked in Big Creek, such as David Redinger, the experience was one that defined their lives.

TECHNOLOGY AND STRUCTURAL DESIGN

Structural Design
Exterior
Powerhouse 1 is a five-story reinforced concrete and steel structure, which measured 171' long, 85' wide, and 104' high on initial construction, and 227' long after its extension in 1925. The walls and floors are constructed of reinforced concrete and supported by steel columns, encased in concrete. The columns are spaced at 14' intervals and form pilasters on the façade. The roof is supported by 6-piece steel trusses in line with the columns.

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[96] "People Who Live in Powerhouses," *Edison Partners*, 11.
[97] For more discussion of the Edison Clubs and their social role, see Shoup, *Life at Big Creek*, 6-8.
[98] Edison Club #28, "Minutes of regular monthly meeting, held Thursday, October 5th, 1933," in Archive Room, Big Creek Powerhouse, 2/2A; Edison Club #21, "Minutes, Regular Meeting, December 3, 1931," in Archive Room, Big Creek Powerhouse 1.

CA-167-E-59 through CA-167-E-61 are construction drawings showing elevations of the plant after its extension in 1925. Also see views CA-167-E-1 through CA-167-E-6 for external views.

The arrangement of windows follows the structural frame and corresponds to the arrangement of floors in the building. On the south façade, there are four window openings in each bay between pilasters. The lower two correspond to the generating floor (which spans the height of the first three floors), and the upper two to the fourth and fifth floors. Window arrangement on the north façade corresponds to the different arrangement of floors, with two smaller window panels lighting each bay on the first and second floors. The fourth floor windows span the same height as on the south part of the building. However, the fifth floor of the north façade has a projecting canopy rather than windows.

The first, second, fourth, and fifth floor windows feature a central double-hung sash in the lower central part of the window opening, with fixed sash on the sides and top. The third-floor windows, at the top of the generator room, feature three sash panels, each of which open around a horizontal central pivot, presumably so that they could be operated mechanically from the generator floor below. All window sash is framed in wood. Views CA-167-E-81 through CA-167-E-85 illustrate the construction of the window sash in detail, while View CA-167-E-6 shows the window openings in the south façade in detail.

The roof has a slight pitch to front and rear for drainage, forming a gable at the east and west elevations, and was equipped with gutters and downspouts of sheet metal. On top of the roof were also located two lightning arrester towers, two horn gap towers, and two A-frame towers.[99] With the towers, the building reached a total height of 138'.

Interior Space

The interior space of the building is shaped by the placement of the structural columns. Two lines of columns spaced 14' apart run the length of the building and support the upper floors. The columns establish two discrete areas of interior space. Between the south wall and the first row of interior columns is the main generator floor, a space 43'-9" wide and 45' high running the length of the building and spanning the height of the first three floors. The first and second row of columns are 20' apart, and another 18' space separates the second row of columns from the north wall. The plant is thus divided into a 'front' or generator portion of the building and a 'rear' portion that housed offices, control rooms, and switching equipment (Views CA-167-E-71, CA-167-E-72).

On construction in 1913, thirteen files of structural columns 14' apart were constructed, giving the plant a total width of 171'. Since the plant was designed for expansion, the east end of the plant was a temporary wall, framed in timber and covered in stucco on metal lath. On original construction, the I-beams at the level of the fourth and fifth floor ceilings were left projecting outside the east side of the building. The Stone and Webster plans for the building show space for the addition of three more files of structural columns, for a total of sixteen (see Views CA-

[99] Kelley, *Price Book*, 250.

167-E-64, CA-167-E-65, CA-167-E-67, CA-167-E-66, CA-167-E-70). However, when the plant was extended in 1925, four files of columns were added for an additional 56' of length. Only one of these was completed to the full height of the building; the others were completed only to the height of the third floor (see Views CA-167-E-2, CA-167-E-59 through CA-167-E-61).

Basement
The basement of Powerhouse 1 sits on a foundation of reinforced concrete extending to bedrock. The front or southern part of the basement holds the pits for the turbines and generators (CA-167-E-70). The oil pump room (CA-167-E-76) is located in the front center of the building, between the pits for Units 1 and 2 and those for Units 3 and 4. In the rear, or northern, portion of the basement were located the penstock entries (CA-167-E-56, CA-167-E-57) transformer oil tanks, the oil treating room, ductwork, and the exciter tailraces. Views CA-167-E-54 and CA-167-E-55 show general views of basement spaces, while CA-167-E-58 shows the Unit 1 governor oil sump.

First (Generator) Floor
The front or southern part of the first floor is the main generator floor, which reached a height of 45' and ran the length of the building. Two of the four generating units were installed at the west end of the building in initial construction, while a temporary wooden floor was installed over the eventual location of Unit 3 (CA-167-E-64).

View CA-167-E-7 shows the generator floor looking east. View CA-167-E-16 provides detail of Unit 2 governor and pressure regulator, while Views CA-167-E-14 and CA-167-E-15 show Unit 4, the Unit 4 exciter, and the Unit 4 oil tank.

In the northern or rear portion of the building, transformer banks were located directly behind the generators, each with three transformers. The banks were separated from each other by barrier walls consisting of galvanized iron on shiplap.[100] On initial construction in 1913, space was set aside for a third transformer bank behind the eventual location of Unit 3, but was initially used only to house one spare transformer of the same type. The transformer banks, like the generator room, spanned the first three floors to a height of 45'. View CA-167-E-23 shows the former Unit 3 transformer bay, now used for storage.

At the centerline of the building, between transformer banks, were located the Unit 1 and 2 exciters and exciter wheels. Views CA-167-E-19 through CA-167-E-21 show the Unit 2 (or spare) exciter and exciter wheel governor. Behind the transformer banks along the north wall of the building were located the oil storage room and the generator rheostats. The two agitators were located immediately behind and in a line with the exciters. Behind the Unit 3 transformer bank, at the northeast corner of the building, was located the battery room.

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[100] Kelley, *Valuation*, 167.

Along the roof of the generator room ran a 85-ton capacity Cleveland Electric traveling crane, which allowed installation and movement of equipment within the plant.[101] Views CA-167-E-24 through CA-167-E-26 show the traveling crane in late 2009.

Second Floor

Because of the height of the generator room, the second and third floors were partial floors, located only in the rear (northern) part of the building.

The second floor is 12' high and consists of the control room at the center of the completed building and a gallery along the rear (north) wall of the building (CA-167-E-65). The control room, which was originally reached by two staircases from the generating floor (since removed), contained the switchboards and allowed operators to see the entire generating floor through the windows. In the gallery, an office and lavatory were located behind the control room, while the western portion was occupied by the 6.6kV bus equipment. Each bus was installed in separate chambers with 12" thick concrete walls (CA-167-E-65, CA-167-E-71, CA-167-E-72).[102]

Third Floor

The third floor consisted of a storeroom above the control room and a gallery along the rear (north) wall of the plant. The 6.6kV oil switches were located in the gallery, allowing switching for station power, the transformer banks and the generators. Behind the storeroom at the centerline of the completed building were located the exciter starting switches and a staircase leading down (CA-167-E-66 and CA-167-E-71 through CA-167- E-73).

Views CA-167-E-35 through CA-167-E-37 show the third floor gallery. CA-167-E-38 shows the current station battery array.

Fourth and Fifth Floors

The fourth and fifth floors were full floors occupied the entire area of the building. Each floor contained two sets of six General Electric 150kV oil switches and the associated high tension bussing equipment, for a total of four sets of high tension switches. This duplication allowed each transformer bank to be connected to either the west or east transmission lines.

The fourth floor was 26'-3" high, with parallel rows of equipment running the length of the building. The high tension bus room occupied the southern or front portion of the floor, the 150kV oil switches stood in a line in the center aisle, and two sets of 150kV lightning arresters were place along the north wall, connected to the lightning arrester towers on the roof. The oil switches were partially enclosed by concrete walls.[103] Two barrier walls 12' high consisting of 2" of plaster on metal lath ran the length of the building, separating the oil switches from the high-tension bus room and from the lightning arresters. These walls would serve to impound oil in case of accidental discharge from the oil switches.[104] The lightning arrester rooms were

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[101] Kelley, *Valuation*, 78.
[102] "The 150,000-Volt Big Creek Development-II," *Electrical World*, January 10, 1914, 85.
[103] "150,000-Volt Big Creek Development-II," 87.
[104] Kelley, *Valuation*, 167.

located on the lower fourth floor, which extended 9' below the level of the upper 4th floor, giving the rooms a total height of 35'-3" (CA-167-E-67 and CA-167-E-71 through CA-167-E-73).

Views CA-167-E-45 through CA-167-E-49 show the upper fourth floor. Note the removal of the busses from this area, and the continued presence of the station light and power transformers. Views CA-167-E-40 through CA-167-E-44 show the lower fourth floor, formerly occupied by the lightning arresters.

On the fifth floor, the area occupied by the lighting arresters on the fourth floor was occupied by the transmission lines, which exited the building under the 14' canopy extending from the northern façade of the building. Otherwise, this floor mirrors the layout of the fourth. Views CA-167-E-50 through CA-167-E-53 show the fifth floor in late 2009, when it was used largely for storage.

Mechanicals and Operation

General

Hydroelectric plants such as Big Creek Number 1 convert the mechanical force of falling water into electrical energy through electromagnetic induction. Water flows through long tubes known as penstocks and is then directed through a nozzle onto the buckets of the turbines, causing them to rotate. The turbines are directly connected to the generator shaft, causing it to turn. A governor is attached to each wheel, allowing the operator to control the speed of the wheel by reducing or increasing water flow against the buckets.

The generator consists of two magnetized copper coils, one rotating (rotor) and the other stationary (stator). To generate power, the rotor coils must be energized by the input of direct current (DC) from an exciter (a separate motor or generator), which produces a magnetic field. The rotation of the magnetized rotor field against the stator windings produces electromagnetic flux and induces alternating current (AC) in the stator's output terminals.

Current from the generators is sent through step-up transformers, which increase the voltage to a level desirable for transmission, and then into transmission lines leaving the plant. Between the generator and transformer, low-tension switches allow electric current from the generators to be sent to different banks of transformers. Between transformers and transmission lines high-tension switches allow current to be switched between different transformer banks and transmission lines. Having parallel sets of generating, bussing, transforming, and transmission equipment allows generation to continue even when individual elements of the system must be taken offline for maintenance or due to mechanical problems.

Despite the complexity of the plant, the equipment in Powerhouse 1 was procured from a limited number of suppliers. The Allis-Chalmers division of I.P. Morris and Co. (Milwaukee, Wisconsin) supplied almost all of the hydraulic equipment, including nozzles, needles, main turbines, exciter turbines, and governors. The electrical equipment for Units 1, 2, and 3, including the generators, exciters, rheostats, transformers, switches, control panels, and busses, was manufactured by the General Electric Company. Westinghouse supplied the equipment for

Unit 4. See CA-167-E-64 for the plan view of Units 1 and 2 and CA-167-E-80 for the plan view of Unit 3.

The narrative below describes the equipment on its original installation. See 'Alterations and Additions' below for a narrative of changes to the plant. A main source of data about Powerhouse 1 is found in the *Valuation, Unit Cost Development*, and *Price Book* for the plant, prepared by Arthur Kelley and his staff in 1922. Kelley was a consulting valuation engineer who prepared detailed inventories of the Big Creek plants and their contents between 1922 and 1932.

Hydraulic

Penstocks, Valves, and Nozzles

The penstocks for Units 1 and 2 were manufactured by Mannesman Rohrenwerke of Düsseldorf, Germany, and were made of lap-welded steel. Each section is 26' long, and narrows from 42" diameter and 3/8" thickness to 24" diameter and 1 inch thickness. Eight hundred feet behind the powerhouse, each pipe divides into two 26" lines each leading to a 24" hydraulically operated valve. The valves, manufactured by Allis-Chalmers, are designed to tolerate pressures up to 1,000 psi. On the other side of the valves are located adjustable nozzles which direct water at the turbine buckets. When fully open, these nozzles were designed to emit a jet of water 5½" wide at 350' per second.[105]

Turbines

The generating units at Powerhouse 1 are double overhung horizontal impulse turbines of the Pelton type. In an impulse turbine, the kinetic energy of the water as it exits the nozzle is absorbed by the buckets of the turbine and transformed into momentum (impulse), leaving the water with diminished velocity. A "double overhung" turbine is one in which two separate waterwheels, one on each end of the shaft, provide the motive force for the generator. Placing one waterwheel on each side produces an even torque on the generator shaft.

The turbines for Units 1 and 2 were manufactured by Allis-Chalmers and were rated for 20,000 horsepower (10,000 from each wheel) at 2131' of head and 375 rpm. Each wheel has nineteen buckets and is 94" in diameter. Units 1 and 2 bear Allis-Chalmers serial numbers 338 and 339, and were purchased on Contract No. 12699. Installed by Stone and Webster in August and September 1913, each waterwheel assembly cost $29,266.49 including the shaft, bearings, runners, needles, nozzles and housings.[106] As *Electrical World* noted in its profile of the plant, "apart from operating under one of the highest heads thus far developed, these wheels are the largest of their type ever built."[107] Each pair of wheels along with its shaft weighed over 100 tons when installed. Unit 3 (1923) was also supplied by Allis-Chalmers and had similar specifications to Units 1 and 2. Unit 4 (1925), however, was supplied by Pelton. View CA-167-E-16 shows Unit 2, while CA-167-E-14 and CA-167-E-15 show Unit 4.

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[105] Jessup, "High-head Hydroelectric Power Development," 193-211.
[106] Kelley, *Valuation*, 105-108; Kelley, *Unit Cost Development*, 252; Kelley, *Price Book*, 150.
[107] "150,000-Volt Big Creek Development-I," 36.

Governors
The governor was used to control the speed of the turbines by regulating water flow. Units 1 and 2 were equipped with Allis-Chalmers, Size 2 Oil Pressure Type automatic turbine governors. The governors controlled the needle valves at the end of the intake nozzles, allowing variation of the flow of water against the turbine buckets. In this way the turbine could rapidly change speed in response to fluctuations in load and automatically limited the speed of the generator so that it could not supply more than a predetermined amount of power. The turbines were also provided with relief valves and hand controls in case manual adjustment was necessary.[108] View CA-167-E-17 shows the Unit 2 governor and pressure regulator.

Exciter Wheel
The Unit 1 and 2 exciters in Powerhouse 1 are connected to a single Allis-Chalmers Type B-1 350hp impulse turbine, which rotates at 750 rpm under 1900' of head. The wheel is 47" in diameter and contains twenty-four buckets. The wheel for exciter Units 1 and 2 bears Allis-Chalmers serial numbers 365 and 366 and cost $2,279.74, inclusive of housing, buckets, needles, and nozzles. The exciter wheel was also equipped with its own governor. At Powerhouse 1 this was an Allis-Chalmers Size 0 Oil Pressure Type Turbine Governor.[109] The Unit 4 exciter wheel is direct-connected to the generator shaft and is powered by the main turbine. Views CA-167-E-19 through CA-167-E-21 show the Unit 2 (spare) exciter, exciter wheel, and exciter governor.

Oil Pump Wheel
The generator bearings and governor valves were lubricated by oil circulated by two central oil pressure pumps. A 25hp Allis-Chalmers Impulse Wheel powered the pumps, which were each connected to the water wheel by a clutch. Each pump was also flange-connected to one of two 35hp, 220V, 715 rpm Allis-Chalmers Induction Motors. This enabled the pump to be operated by either water power or electrical power depending on the needs of the plant.[110]

Tailrace
Water exits the turbines into the forebay through a short tunnel called a tailrace. The Judson Manufacturing Company of Oakland, California furnished the steel tailrace linings.

Spare Parts
A variety of spare parts were furnished for the hydraulic machinery after initial construction in 1913. These included three needle tips, two nozzle tips, one set wheel buckets and one cross-head for main wheels; two nozzle tips, two needle tips and one set wheel buckets, one regulating valve, and two sets of metal packing rings for the main governors.[111]

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[108] Kelley, *Unit Cost Development*, 253.
[109] Kelley, *Valuation*, 106; Kelley, *Price Book*, 151.
[110] Kelley, *Valuation*, 108; "150,000-Volt Big Creek Development-I," 36.
[111] Kelley, *Valuation*, 109.

Electric

Generators

In the initial construction of Powerhouses 1 and 2, Pacific Light and Power purchased electrical equipment from both Westinghouse and General Electric. Powerhouse 1 used generators and transformers from General Electric, while Powerhouse 2 used Westinghouse equipment. In Powerhouse 1, the Unit 1 and 2 waterwheels powered General Electric type ATB, Form A generators rated at 17,500 kilovolt-amperes (kVA), at 6.6kV and 375 rpm.[112] Purchased on contract number 12701, these units bear GE serial numbers 559520 and 559521.[113] Each unit weighed 78 tons at installation.

Unit 3 was also supplied by General Electric, and also generated 17,500 kVA at 6.6kV on its installation in July 1923. Unlike the other three generators, Unit 4 was supplied by Westinghouse and had a rating of 28,000 kVA, 11kV, and 1,470A on installation.[114]

Exciters

As noted above, the exciters energize the magnetic field in the generator rotor, which as it rotates induces electric current in the stator. Two exciters were installed in initial construction, both connected to a single impulse wheel (see 'Exciter Wheel' above). The Unit 1 exciter, however, was also connected through a flanged coupling to a 225 HP motor, allowing both hydraulic and electrical operation. The Unit 1 and 2 exciter generators were 150kW General Electric type DMC, Form L, 6 pole, 750 rpm, 250V, bearing GE serial numbers 388659 and 388660.[115] The Unit 4 exciter, supplied by Westinghouse is direct-connected to the generator shaft.

Low-Tension Bus

The generators fed current at 6.6kV into the low-tension bus room, originally located on the second floor. The buses were controlled from the low-tension oil switch room on the third floor, which used General Electric K-3 6.6kV oil switches. Two complete sets of bus equipment were initially provided, allowing current from either generator to be sent to either bus (see CA-167-E-65).[116]

Transformers

On initial construction, two banks of three transformers were provided in Powerhouse 1, plus a spare transformer that was placed in the area where Unit 3 would later be installed. The transformers were General Electric 5833 kVA, Type WC, Form E-1. Oil insulated and water-cooled, the transformers converted the 6.6kV from the generators to the 150kV used for transmission on the Big Creek lines prior to 1923. The initially installed transformers were GE serial numbers 989961, 989963, 989964 (Bank 1); 989965, 989966, and 989967 (Bank 2); and

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[112] A volt-ampere is the product of voltage and current and expresses potential power. In direct current (DC) systems kilovolt-amperes are equivalent to kilowatts. In alternating current (AC) systems, however, voltage and current are sinusoidal and may be out of phase, yielding less power (fewer kilowatts).

[113] Kelley, *Valuation*, 114; Kelley, *Price Book*, 166.

[114] "Big Creek-San Joaquin Hydro-Electric Project," 33; Southern California Edison, "Memorandum," 2.

[115] Kelley, *Valuation*, 120; Kelley, *Price Book*, 203-204.

[116] "150,000-Volt Big Creek Development-I," 85.

989962 (spare).[117] The transformer banks at initial installation in 1913 are shown on CA-167-E-64.

High-Tension Bus
From the transformers, the 150kV current arrived in one of the high-tension bus rooms on the fourth or fifth floors. The switches for each high-tension bus were located on the same floor, and were General Electric 150kV oil switches of the K-21 type. Two complete sets of bus equipment were provided for each transformer bank, for a total of four sets. This allowed either transformer bank to feed power into either of the two transmission lines leaving the plant.[118] Views CA-167-E-67, CA-167-E-68, CA-167-E-73, and CA-167-E-74 show the high-tension switches and busses.

Transmission Lines
Two transmission lines were constructed in the Big Creek initial development, and traveled 241 miles to the Eagle Rock substation in Los Angeles. Called the "East" and "West" lines, each line exited the plant at two points, one at the fourth floor high-tension bus, and one at the fifth-floor high-tension bus. The leads of the transmission lines were sheltered as they left the plant by a canopy projecting 14' from the north façade of the powerhouse.

Lightning Arrester and Horn Gap Towers
The plant as originally constructed was furnished with two lightning arrester towers and two horn gap towers on the roof. These towers served to ground arcs or lightning that might touch the power line. The lightning arresters sent such charges into tanks located on the lower fourth floor of the powerhouse structure.[119] The towers extended approximately 30' upward from the roof of the powerhouse (CA-167-E-69).

Control and Maintenance
Control room
The main switchboard was also purchased from General Electric and included fifteen panels on which switches and gauges were mounted.[120] As *Electrical World* noted:

> The main switchboard, which is of the bench type, is located in a gallery in the center of the operating room, immediately above the exciter bay, and by remote control it governs the generators, transformers, switch operation and auxiliary control of governors and exciter motors.[121]

The exciters and generator field boards, however, were located in the first floor exciter bay, while a small upright switchboard in the second floor gallery controlled the storage battery and station light and power functions.

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[117] Kelley, *Valuation*, 166-167.
[118] Kelley, *Unit Cost Development*, 318; "150,000-Volt Big Creek Development-II," 85-86.
[119] Kelley, *Unit Cost Development*, 318.
[120] Kelley, *Price Book*, 173.
[121] "150,000-Volt Big Creek Development-I," 38.

Crane
The generator room was supplied with a traveling crane to move machinery within the plant. Supplied by Cleveland Electric, the crane was electrically powered with a capacity of 85 tons. It had a span of 40' and a run of 168'4" (later extended).[122] Views CA-167-E-24 through CA-167-E-26 show the traveling crane in late 2009.

Alterations and Additions
Powerhouse 1, like the other powerhouses in the Big Creek system, is a working industrial facility and has been in continuous operation since its construction in 1913. As such, it has been subject to regular maintenance and overhaul of equipment. This section details only major modifications to the plant.

Powerhouse 1 saw relatively few modifications in the first 10 years of its operation. A large electric sign reading "Southern California Edison Company" was added to the south façade of the plant by January 1921, when an archival photograph shows the sign in place.

The first major modification to the plant came in late 1922 and early 1923, when the entire Big Creek system was converted to 220kV transmission. To effect this conversion, new transformers and switches were installed in the plant. A set of six outdoor transformers at Big Creek #1 is shown in an archival photograph dated April 29, 1923.

About the same time, construction began on the long-planned third generating unit, which came online on July 12, 1923. Construction of the third unit required the removal of the temporary wooden floor over the Unit 3 generator pit, the installation of tailrace linings, and the removal of the temporary end of the building (see CA-167-E-63, CA-167-E-80). Like Units 1 and 2, Unit 3 was a GE 17,500 kVA, 6.6kV generator.[123] The transformers supplied for the unit, however, must have been rated for 220kV, since the entire Big Creek system had been converted to that voltage on May 12, 1923.[124]

Powerhouse 1 was completed to its current dimensions with the installation of Unit 4 in June 1925 (See CA-167-E-60 and CA-167-E-61). Installation of the fourth unit required the extension of the powerhouse by 56' (four 14' column lengths) for a total length of 227'. Only part of the extension, however, was constructed to the full height of the building. As the *Journal of Electricity* explained, "above the fourth floor line it will be necessary to make only a 14-ft. extension as the additional bus and switching equipment takes up less room than the generating unit."[125] Unlike the other three generators, Unit 4 was supplied by Westinghouse and had a rating of 28,000kVA, 11kV, and 1,470A on installation.[126]

In 1930 a new outdoor substation was constructed for Powerhouse 1 in the rear of the plant, and the interior substation equipment on the 3rd, 4th, and 5th floors was dismantled. In 1932

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[122] Kelley, *Valuation*, 78.
[123] Southern California Edison, "Memorandum," 1.
[124] "Transmission at 220,000 Volts," 1107.
[125] "Big Creek No. 2," 212.
[126] "Big Creek-San Joaquin Hydro-Electric Project," 33; Southern California Edison, "Memorandum," 2.

Exciters 1 and 2 were converted to remote control, while Governors 1 and 2 were wired for remote starting. In 1933 and 1934 new buckets were installed on the waterwheels for Units 1 and 2. In 1936 the main switchboard panels were replaced.

The coils of each generating unit have also been rewound for maintenance and to increase generating capacity, although the generator cases maintain their original appearance. Units 1 and 2 were rewound for maintenance and repair purposes in the 1940s, 1960, and 1979. Unit 3 was rewound in 1949 for generation at 13.2kV and 766A. Unit 4, originally installed for operation at 11kV, was also rewound for 13.2kV in 1970.[127]

CONTEXT AND SIGNIFICANCE

Preservation

Environmental Setting

The setting of Powerhouse 1 has changed only in minor ways since 1913. The dramatic view from the powerhouse to Kerckhoff dome, over 1400' above, remains unobstructed by further construction. Frontal views of the powerhouse from across the valley, however, are today partially obscured by the regrowth of forest cover in the Big Creek area. The main approach to the western side plant from Big Creek town is partially obscured by the large steel catwalk and monorail.

Structural/Façade

From outside, Powerhouse 1 appears much as it did on completion of Unit 4 in 1925 and preserves the appearance intended by the original designers, with the exception of the "Southern California Edison" sign constructed by 1922. The steel catwalk and monorail providing access to the 5th floor was installed sometime after the 1920s, for it is not visible in archival photos. The concrete and steel elements of the structure are well maintained.

Views CA-167-E-1 through CA-167-E-6 show external views of the structure in late 2009.

First (Generator) Floor

The turbines, generating units, and generating room overall appear as they did on first installation. Routine maintenance has been performed on the equipment, including replacement of turbine buckets and rewinding of generators. However, the turbines, generators, governors, and many gauges remain in their original casings. The governor equipment now stands in cabinets (see CA-167-E-8), which changes the appearance of the generator floor. The rear portion of the first floor originally housed the transformers and the oil storage room and now are used as a machine shop and storage (Views CA-167-E-23, CA-167-E-27). The power transformers were moved to an outside switchyard around 1923.

[127] Southern California Edison, "Memorandum," 2.

Second Floor
The control room has been substantially modified from its original appearance by the replacement of the original boards, the removal of the external stairways, and the addition of computers and other modern office equipment.

Third - Fifth Floors
The low-tension bus, transformers, and high-tension bus were originally located on the upper floors. An outside switchyard was constructed by 1923, leading to the removal of the equipment in the original bussing and switching rooms. The third floor now holds a battery room. The lower fourth floor is used for storage. The upper fourth floor contains station light and power transformers and disconnects, while the fifth floor is used for storage.

Roof
With the removal of the high-tension bus from the generation building, the horn gap and lightning arrester towers were no longer necessary. These towers were removed by 1925.

Window Sash and Doors
The window sash in Powerhouse 1 is almost all original. While broken panes have been replaced, most lights remain in their original wooden frames throughout the powerhouse, with the exception of a small section on the fourth floor. The original wooden external doors, however, have been replaced with metal equivalents since the construction of the plant.

The excellent state of preservation, continuity of use, and integrity of setting appear to present sufficient integrity to convey the significance of the structure.

Significance
Big Creek Powerhouse 1 is a NRHP-eligible structure of statewide significance, part of a district of national significance. As the discussion above suggests, the powerhouse retains substantial structural and functional integrity.

At the time of its construction the plant, along with its twin Powerhouse 2, was one of the highest-head hydroelectric developments in the western United States. The waterwheels and generators were among the largest of their type ever constructed, and the powerhouse was the first in the world to transmit electricity commercially at 150kV. The Big Creek system was also the premiere example of the transition from the construction of isolated power plants serving local markets to the construction of large systems integrated with distant energy markets via high-voltage transmission. Powerhouse 1, as the first plant in the system, is especially symbolic of this important logistical and technological innovation in the design of electrical transmission and generation systems.

The Big Creek system is also significant in the history of the Los Angeles region. Conceived as a means of powering both residential development and electric railways, power from Southern California Edison's Big Creek plants was instrumental in the rise of suburban development in the region. The system is closely associated with railroad, energy, and development magnate Henry Huntington; with Edison executives and power pioneers A.C.

Balch, William Kerckhoff, and George C. Ward; visionary California hydroelectric engineer John Eastwood; and longtime Big Creek manager David Redinger.

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- Bancroft Library, University of California, Berkeley, California
- Engineering Library, University of California, Berkeley, California
- University of California Northern Regional Library Facility, Richmond Field Station, Richmond, California
- Philadelphia Free Library, Philadelphia, Pennsylvania
- Southern California Edison Collection, Huntington Library, San Marino, California
- Plant Accounting Department, Southern California Edison Company, Rosemead, California
- Northern Hydro Division Headquarters, Southern California Edison Company, Big Creek, California
- Big Creek Powerhouse 1, Big Creek, California
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APPENDIX A

Historical photographs of Big Creek Powerhouse 1 are held in the Southern California Edison collection at the Huntington Library, San Marino, California. The following photographs in the collection illustrate the plant between 1917 and the mid-1920s.

- 02-04042
- 02-05053
- 02-07326
- 02-13257
- 02-28821
- 02-13821
- 02-06576
- 02-0598A
- 02-12785